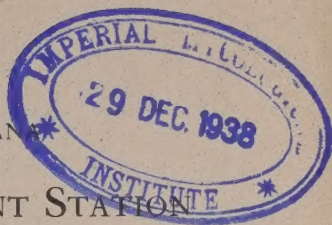


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Plum Pocket and Leaf Gall on Americana Plums

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IMPORTANCE OF AMERICANA PLUMS

Montana is situated practically at the northern limits of plum production. The more tender of the European and Japanese varieties cannot be grown in any part of the State. In the more favored locations west of the continental divide a number of good varieties, such as Bradshaw, Peach, Pond, and Tragedy, that are moderately hardy, can be grown very successfully; but throughout the greater part of the State, including all that vast region east of the continental divide, about the only plums that succeed are the native wild plum (*Prunus Americana* Marshall) and cultivated varieties and hybrids of this species, such as DeSoto, Hawkeye, Wolf, and Wyant. Indeed, much of the north central portion of the United States is largely dependent upon the Americana plums. Hedrick (36) says of it (p. 59), "The domestication of Americana plums is due to the fact that the plums of Europe will not thrive in the Mississippi Valley, the prairie states, nor, for the most part, in the south. The European species are tender both to cold and heat in these regions and they are attacked by those scourges of plum culture, black-knot, leaf-blight, and curculio."

Under these conditions the native plum and its hybrids and horticultural varieties are of peculiar importance. They are easily propagated, thrive under diverse soil conditions, and are not often damaged even by our severest winters. While the fruit is not so large or so good in flavor or texture as many European and Japanese plums yet it is highly prized, and during the last ten years it has actually sold in Montana markets at as high a price as the more standard varieties.

ENEMIES OF THE PLUM IN MONTANA

The growing of Americana plums in this State has been greatly hampered and finally brought to a standstill by a fungus disease and an insect pest, namely, a plum pocket caused by *Taphrina communis* (Sad.) Gies., and a leaf-gall mite, *Eriophyes pruni* Schoene. A leaf curl caused by *Taphrina decipiens* (Atk.) Gies. is of minor importance. With the control of the plum pocket and the leaf-gall mite as described below the planting of these plums may well be encouraged.

PLUM POCKET

The term "plum pocket" is applied to a group of related diseases of plum and cherry in which the fruits become greatly inflated and hollow.

Cause.—There are two forms of plum pocket of especial interest to orchardists. One is caused by *Taphrina communis* (Sad.) Gies., found mostly on *Prunus Americana* and cultivated varieties derived from it but also reported on *P. maritima* Wang., *P. niger* Ait., *P. pumila* L., and *P. subcordata* Benth. The other is caused by *T. pruni* (Fcl.) Tul. and is troublesome on many different varieties including the European plums, but rarely occurs on *P. Americana*. These fungi are closely related, similar in appearance, and cause similar symptoms. *T. pruni* does not occur in Montana at this time so far as we know. This discussion will, therefore, be confined chiefly to the disease caused by *T. communis*.

When the spores of this fungus attack the fruit the mycelium from them does not at once grow throughout its tissues but is chiefly confined to the epidermis, forcing its way underneath the cuticle. (Fig. 1 a.) A few strands, however, go deeper into the fruit. A few weeks later the fungus breaks out through the cuticle, producing enormous numbers of asci over the entire infected surface, and each of these forms quite regularly eight ascospores. As reported by various authors—Sadebeck (61), Mrs. Patterson (51), and Giesenhagen (28)—these ascospores later divide into numerous conidia. In our material we have found that the ascospores at first possess one nucleus (fig. 1 c), but later, in preparation for the formation of conidia, this nucleus divides into two (fig. 1 d) or even several nuclei. These same authors report the wintering over by a perennial mycelium in the fruit-bearing twigs. We have not made an exhaustive study of this phase of the subject, but we are convinced that most of the twigs bearing diseased fruits do not have such a mycelium and most of the plums are infected by spores and not by direct extension of mycelium from the twigs bearing them. Our success in controlling the disease by spraying would support these microscopical findings. The fungus has been best described by Sadebeck (61), Atkinson (1), Mrs. Patterson (51), and Giesenhagen (28), but they have not made clear its full life history. So far as known only one crop of spores is formed, and these are distributed in midsummer;

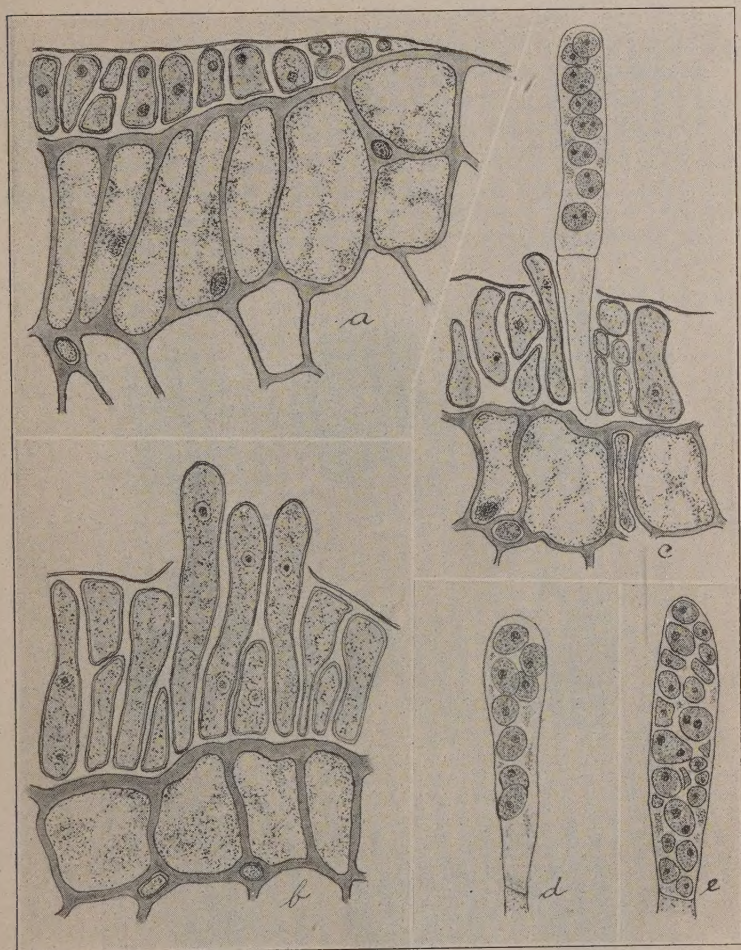


FIG. 1. Sections through infected plums: a, Invasion of fungus under the cuticle of the epidermal cells. b, Fungus breaking through cuticle. c, Ascus with mature binucleate spores. d, Young ascus with uninucleate spores. e, Ascospores dividing to form conidia. All magnified 1110 times.

but at this time the young, healthy fruits seem no longer susceptible to attack. No new fruit infections are known to occur from this time until the next blooming period of the host.

Symptoms.—A week or two after the blossoms wither, when the fruits are one-fourth to one-half inch in diameter, small whitish spots appear on them, usually one to three on each. These are greenish-white in color, much elevated, and very spongy in texture (fig. 2). They enlarge rapidly until usually the entire plum is involved. At

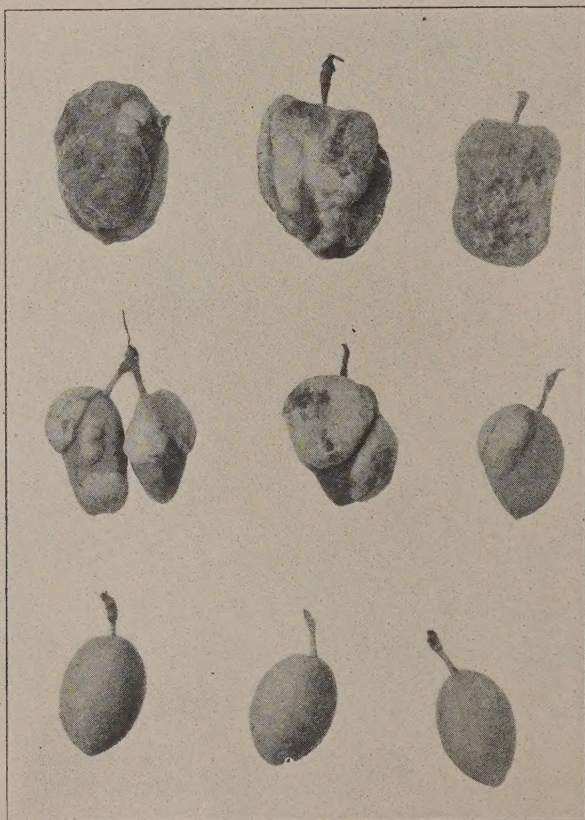


FIG. 2. Healthy and diseased plums, not fully developed, for comparison. Natural size.

this time the stone and seed are only slightly developed and become broken away from the vascular bundles that supply them with water and food and consequently shrivel and disappear. The infected fruits enlarge rapidly and become spongy and then hollow (fig. 3), hence the names "plum pockets," "pocket plums," "bladder plums," and "fools." When full-grown they are three or four times the size of normal plums and leathery in texture. (Fig. 4.) They drop before normal fruit begins to ripen.

Damage done.—Plum pocket is extremely common on Americana plums in central and eastern Montana, and in many other places in

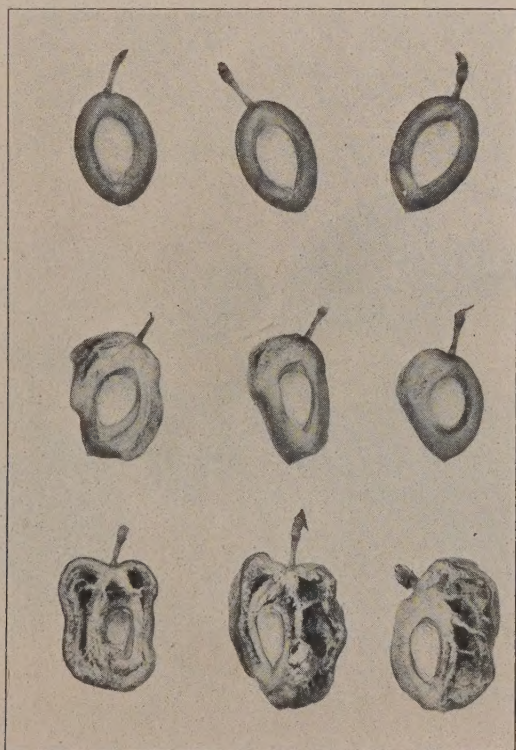


FIG. 3. Internal view of young healthy and diseased plums, showing spongy structure. Natural size.

the Missouri and Mississippi valleys. It usually starts on a few trees in the orchard and gradually spreads to others. When a tree becomes infected it continues to bear diseased plums year after year if left untreated. When the disease has become well established in an orchard it is not unusual to find affected fruits on nearly every tree, and on the worst ones 50 to 90 per cent of the fruits are diseased every year. When a heavy crop is set and the disease is not too severe, it will occasionally result in a proper thinning of the fruit, but this combination is uncommon. We know of entire orchards of good bearing trees having been removed because so few healthy fruits were obtained from them. These orchards were not large, but they were the pioneer test orchards that should have determined whether or not it will be profitable to grow this fruit. Indeed we know of very few plum orchards or even wild thickets in this State east of the continental divide that are free from plum pocket.



FIG. 4. Well developed pocket plum and young healthy ones for comparison in size. Two-thirds natural size.

LEAF GALL

In our experiments for the control of plum pocket we found leaf gall so abundant on some of the trees that it was likely to seriously complicate the results.

Cause.—These leaf galls are caused by a mite (*Eriophyes pruni* Schoene) which hibernates under the bud scales. When the buds open these mites crawl forth, seeking the tender young leaves, which they puncture, forming pimples that soon develop into galls.

Appearance.—The galls when fully developed are one-fourth to one-half inch long and one-eighth inch or less in diameter and strongly tinged with red. They are hollow, and the mites live inside. Most of the galls protrude from the upper side of the leaf, either scattered or in dense tufts. (Fig. 5.)

Damage done.—These galls do not kill the leaves outright, but if numerous they seriously interfere with normal functions. Often they are so numerous as to distort a large portion of the leaf surface of the tree.

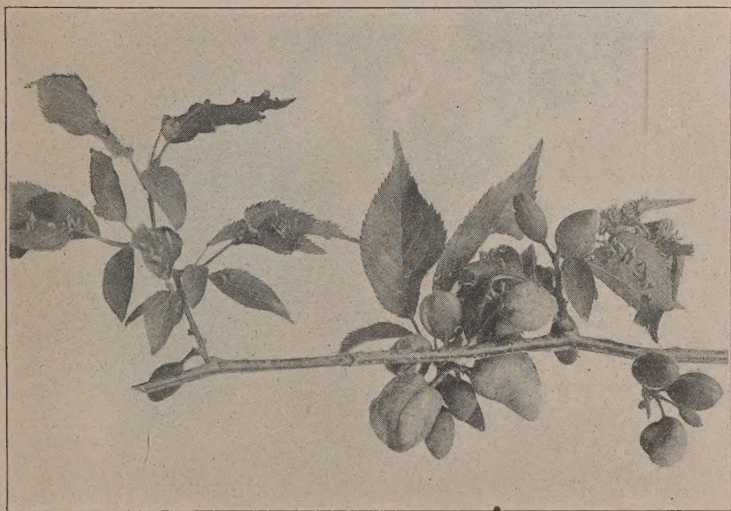


FIG. 5. Twig showing leaf galls and pocket plums. Half natural size.

LEAF CURL

Many of the plum trees in the Yellowstone Valley are more or less affected with a leaf curl caused by *Taphrina decipiens* (Atk.) Gies. (Fig. 6.) This disease has become so abundant in certain trees that considerable damage is done, but for the most part it is scattered, though steadily increasing in prevalence.



FIG. 6. Twig affected with leaf curl. Two-thirds natural size.

CONTROL EXPERIMENTS

In the spring of 1913 the authors, in response to repeated complaints that plum pockets and leaf-gall mites were making plum growing unprofitable, began work intended primarily to find a preventive for plum pocket but incidentally including leaf gall and leaf curl.

Plum pocket.—Some attempts have been made to control by spraying the plum pockets caused by *Taphrina pruni*, but until recently none have been successful. This may be due in part to the fact that until within the last few years Bordeaux mixture was the fungicide generally used for spraying and the plum foliage is very sensitive to burning by this mixture. Kirk (43) recommends spraying for the control of *Taphrina pruni* but does not give experimental data in support of this recommendation. In a very recent paper Stakman and Tolaas (73) have shown that while the plum pocket can not be perfectly controlled by a single season's spraying, yet the cumulative effect of spraying every year will practically eliminate it even from badly infested trees.

We find no records of spraying experiments for *Taphrina communis*.

Our experiments were conducted in three orchards near Billings, Montana, during the years 1913 to 1917, inclusive. These orchards contained a mixture of native wild plum and several cultivated varieties of it. So far as our observations have gone Wolf and Wyant have proven rather susceptible to plum pocket, while DeSoto and Hawkeye were much more resistant.

As plum foliage is easily injured by spray mixtures we made no attempt to use Bordeaux mixture but started out with self-boiled lime sulphur—8 pounds lime and 8 pounds sulphur to 50 gallons of water. The lime was slaked with hot water, and as soon as it was boiling actively the sulphur (flowers) was added. The mixture was stirred until boiling had nearly ceased, after which it was allowed to stand for ten minutes; then enough cold water was added to make a total of 50 gallons. Later, dilute factory-boiled lime-sulphur was used. This was the Hellgate brand manufactured in Missoula, Montana, and testing 28° Baume. It was diluted 1 part to 50 parts of water.

The fungicide was applied during the years 1913-1915 with a Meyers barrel pump and in 1916 and 1917 with a Morrell and Morley

"Eclipse No. 4," maintaining a pressure of about 50 pounds. The hose was fitted with a Bordeaux nozzle.

In 1913 a late spring frost destroyed the crop almost completely.

In 1914 frost destroyed the greater part of the crop, but enough remained to give some results indicating that the disease could be controlled, to some extent at least, by spraying.

In 1915 conditions were more favorable and the results obtained are shown in Table I. In all our work the "dormant" spray was given just before the first winter fruit buds began to break. The "pink" spray was given when nearly all the fruit buds had broken, but only a few flowers had opened. It should be said that different varieties and strains of the plum did not open quite together. The "petal" spray was given when one-half to three-fourths of the petals had withered.

All the trees selected for spraying work and checks were known to have produced many pocket plums.

TABLE I.—SHOWING CONTROL OF PLUM POCKET WITH SELF-BOILED LIME SULPHUR

Tree No.	When sprayed (1915)				Results	
	I Pink	II Petal	III	IV	Total No. fruits	Per cent diseased
1	April 23	.....	.....	.....	450	0.4
2	April 23	.....	.....	.....	400	0.3
3	April 23	.....	.....	.....	500	1.6
4	April 23	May 7	.....	.....	100	0
5	April 23	May 7	.....	.....	250	0
6	April 23	May 7	.....	.....	100	0
7	April 23	May 7	May 19	.....	1300	0.1
8	April 23	May 7	May 19	.....	500	0
9	April 23	May 7	May 19	.....	75	0
10	April 23	May 7	May 19	June 3	1350	0
11	April 23	May 7	May 19	June 3	175	0
12	April 23	May 7	May 19	June 3	200	0
13	.....	May 7	.....	.....	1200	1.3
14	.....	May 7	May 19	.....	1100	1.0
15	.....	May 7	May 19	June 3	1050	0.
16	Unsprayed	.....	.....	.....	900	55.5

Note: On most of these trees the number of healthy plums was carefully estimated rather than actually counted.

Table I shows that spraying can be made quite effective against this disease. On more than half of the sprayed trees not a single

pocket plum could be found, while the highest percentage of diseased fruit was 1.6. The check, on the other hand, showed 55.5 per cent diseased. At the time the fourth application was given the disease was already showing extensively on the unsprayed trees.

To determine whether the effects of spraying extend beyond one year a set of trees sprayed with self-boiled lime-sulphur in 1915 was left unsprayed in 1916 but notes were taken both years on the prevalence of the disease.

TABLE II.—SHOWING THAT SPRAYING OFFERS LITTLE PROTECTION AGAINST PLUM POCKET THE SECOND SEASON AFTER APPLICATION

Tree No.	When sprayed (1915)				Results in 1915		Results in 1916	
	I Pink	II Petal	III	IV	Total No. fruits	Per cent diseased	Total No. fruits	Per cent diseased
1	April 23	.....	.....	.....	400	2.	46	41.3
2	April 23	.....	.....	.....	1000	0.2	54	31.5
3	April 23	May 7	.....	.....	800	0.1	10	40.
4	April 23	May 7	.....	.....	1050	0.1	0	0
5	April 23	May 7	May 19	.....	700	*2.8	2	0
6	April 23	May 7	May 19	June 3	275	0.	20	0
7	Unsprayed	.....	.....	.....	800	75.	.....	.....
8	"	.....	.....	.....	1000	90.	.....	.....
9	"	.....	.....	.....	700	55.	.....	.....
10	"	.....	.....	.....	3000	90.	.....	.....
11	"	.....	.....	.....	.....	.....	428	7.5
12	"	.....	.....	.....	.....	.....	117	20.5

Note 1. On most of these trees the number of healthy plums was carefully estimated rather than actually counted.

*Note 2. All the diseased fruits, 20 in number, on this tree were on one branch, indicating that this branch was missed when the most important application was given.

The season of 1916 was not so favorable to the disease as that of 1915 and it was much less prevalent on unsprayed trees. Also the crop was lighter. Table II indicates, however, that the effects of spraying last only for a season. The comparison is somewhat complicated by the fact that we were obliged to use different check trees in 1916.

In 1916 it was decided to try both self-boiled lime-sulphur and

the factory-boiled product (28° Baume diluted 1 to 50), hoping that the latter would prove equally effective, as its preparation is much simpler for the orchardist. It had also been observed that so many infections were visible within two weeks from the time the petals wither that the later sprays were worthless. Consequently only two applications were given. The results are shown in Tables III and IV.

TABLE III.—SHOWING CONTROL OF PLUM POCKET WITH SELF-BOILED LIME-SULPHUR

Tree No.	When sprayed (1916)		Results	
	I Pink	II Petal	Total No. fruits	Per cent diseased
1	April 20	.....	32	0
2	April 20	.....	17	0
3	April 20	May 9	261	0
4	April 20	May 9	438	0
5	April 20	May 9	0	0
6	April 20	May 9	165	0
7	April 20	May 9	52	0
8	.....	May 9	3	0
9	.....	May 9	174	0
10	.....	May 9	121	0
11	.....	May 9	115	0
12	.....	May 9	146	0
13	.....	May 9	306	0
14	Unsprayed		2	0.
15	"		130	1.5
16	"		25	36.0
17	"		12	41.6

The control by spraying with self-boiled lime-sulphur was absolutely perfect. Not a single diseased plum could be found on a sprayed tree.

The factory-boiled lime-sulphur likewise gave perfect control while the six unsprayed checks (in Tables III and IV combined) with a total of 714 plums had 72 of them diseased, or an average of 10 per cent. As already noted 1916 was a poor year for both plum pocket and plums.

If 1916 was an unfavorable year for plum pocket, 1917 was quite the reverse, both for the disease and for spraying. The weather

TABLE IV.—SHOWING CONTROL OF PLUM POCKET WITH DILUTE COMMERCIAL LIME-SULPHUR

Tree No.	When sprayed (1916)		Results	
	I Pink	II Petal	Total No. fruits	Per cent diseased
1	April 20	-----	2	0
2	April 20	-----	0	0
3	April 20	-----	7	0
4	April 20	-----	2	0
5	April 20	May 9	0	0
6	April 20	May 9	386	0
7	April 20	May 9	0	0
8	April 20	May 9	52	0
9	-----	May 9	980	0
10	-----	May 9	48	0
11	Unsprayed		428	7.5
12	"		117	20.5

records taken at the Billings Weather Bureau station during the month of May show the following daily precipitation:

May 1 0.06 in.	May 8 0.00 in.	May 16 0.00 in.	May 24 0.43 in.
" 2 .02 "	" 9 .00 "	" 17 .00 "	" 25 .06 "
" 3 .00 "	" 10 .00 "	" 18 .00 "	" 26 .04 "
" 4 .49 "	" 11 .00 "	" 19 .02 "	" 27 tr.
" 5 .51 "	" 12 .00 "	" 20 .32 "	" 28 .13 "
" 6 .00 "	" 13 .00 "	" 21 .22 "	" 29 .76 "
" 7 .00 "	" 14 .00 "	" 22 .02 "	" 30 .93 "
	" 15 .00 "	" 23 .00 "	" 31 tr.

From the records it may be seen that the "dormant" and "pink" sprays were given during a period of fair weather, but that the "petal" spray was both preceded and followed by frequent rains.

It had been decided from previous work that the disease could be controlled by a single application of lime-sulphur, and the work of 1917 was principally to confirm this belief and to determine which is the best time for spraying. Consequently each tree was sprayed but once—different groups on different dates.

Table VI shows what can be done to control pocket plum under much less favorable conditions than those during the preceding years of the experiment. The results were by no means perfect, and yet much benefit was derived from the first and the second sprays. The third application, made when most of the petals were withering,

gave little or no benefit either because it was too late or because it was washed off by rain.

TABLE V.—SHOWING CONTROL OF PLUM POCKET WITH DILUTE COMMERCIAL LIME-SULPHUR UNDER UNFAVORABLE CONDITIONS, I. E., A RAINY PERIOD

Tree No.	When sprayed (1917)			Results	
	I Dormant	II Pink	III Petal	Total No. fruits	Per cent diseased
1	May 8	.....	.....	304	1.3
2	May 8	.....	.....	"	"
3	May 8	.....	.....	110	6.4
4	May 8	.....	.....	91	7.7
5	.....	May 16	.....	100	25.
6	.....	May 16	.....	200	13.
7	.....	May 16	.....	1400	.8
8	.....	May 16	.....	70	2.9
9	.....	.....	May 27	700	80.0
10	.....	.....	May 27	400	85.0
11	.....	.....	May 27	450	85.0
12	.....	.....	May 27	*	"
13	Unsprayed	.....	.....	1800	46.0

*Label lost.

From our experiments extending through the last five years we feel very certain that the plum pocket caused by *Taphrina communis* can be controlled without serious difficulty, excepting, perhaps, in regions or seasons having very frequent rains through the blooming period. To what extent the same treatment will control the form caused by *T. pruni* is problematic. The two fungi are very closely related and appear to have very similar life histories. It is probable that in both forms some fruits are infected by the extension of a perennial mycelium in the twigs and others by spores alighting on the surface. There seems little reason to suppose that the infection from a mycelium in the twigs can be controlled by spraying, nor, on the other hand, that the infection by spores can not be so controlled. It seems fair to expect, then, that *T. pruni* can be controlled by spraying to whatever extent the spores are responsible for fruit infections, and the work of Stakman and Tolaas, reviewed on page 175, supports this expectation. We have had no opportunity in this State to test the applicability of this hypothesis.

Leaf-gall mite.—Leaf galls were so prevalent on many of the

trees used in experiments for the control of plum pocket that it was thought best to devise some means of reducing them. Accordingly in 1914 all the trees used in that season's work were given a late "dormant" spray of lime-sulphur, 28° Baume, diluted 1 to 6. Only a small number of galls appeared on any of these trees. In 1915 it was noted that none of the trees that were sprayed as indicated in Table I had many galls, while the check tree and many others in the orchard were badly infested. The results in 1916 were similar.

These tests indicated that if trees are sprayed in the dormant condition or in the pink, even with dilute lime-sulphur, the number of galls is greatly reduced, but as no records had been made the previous season on the prevalence of the galls on these trees and as some of them undoubtedly were freer from it than others, a more definite experiment on a small scale was planned. In the summer of 1916 a number of plum trees on which the galls were very abundant were selected and labeled. In 1917 these were sprayed with Hellgate lime-sulphur, 28° Baume, diluted 1 to 50. The results are shown in Table VI.

TABLE VI.—SHOWING CONTROL OF LEAF MITE WITH DILUTE FACTORY-BOILED LIME-SULPHUR

Tree No.	When sprayed (1917)		Results
	I Dormant	II Pink	Prevalence of mite galls
1	May 8	.....	Very few
2	May 8	.....	Very few
3	May 8	.....	None
4	.....	May 16	Abundant
5	.....	May 16	Very abundant
6	.....	May 16	Very abundant
7	.....	May 16	Very abundant
8	Unsprayed		Very abundant
9	Unsprayed		Very abundant

From this table we can see that the "dormant" spray, even quite dilute, reduced the mite to such an extent that little damage was done, but that the "pink" spray had little effect upon it. In 1915 and 1916 the "pink" spray gave good control but the "petal" spray much poorer.

Plum leaf curl.—In the summer of 1916 a number of trees showing leaf curl and twig distortions caused by *Taphrina decipiens*

were selected and labeled. In the spring they were sprayed with Hellgate lime-sulphur, 28° Baume, diluted 1 to 50, and each tree was given a single application, three of them in the dormant condition, two of them in the pink condition, and three of them when the petals were withering. No apparent benefit was derived in the control of the leaf curl. This was not surprising, however, as the mycelium quite regularly hibernates in the twigs and the spread by spores to healthy twigs is very slow.

CONCLUSIONS

1. The native plum and varieties derived from it are about the only ones that can be grown successfully in central and eastern Montana.

2. These plums are highly prized and sell for good prices in Montana markets.

3. The growing of these plums has been made unprofitable by plum pocket and leaf-gall mite.

4. The plum pocket can be very well controlled by spraying with lime-sulphur,—either self-boiled 8-8-50, or factory-boiled 28° Baume, diluted 1 to 50, or 32° Baume, diluted 1 to 60.

5. Only a single application is necessary, and this may be given at any time from a late dormant condition to the time the flowers begin to open.

6. The effects of spraying appear not to extend over more than one season.

7. Both microscopical examination and the results of spraying indicate that while a perennial mycelium occurs in some twigs most of the fruits are infected by spores.

8. To what extent the measures here used to control *Taphrina communis* will affect *T. pruni* remains to be proved, but it seems well worth while to try "dormant," "pink," and "petal" sprays on it.

9. The leaf-gall mite of plum is easily controlled by spraying with dilute lime-sulphur while the trees are still dormant, and in some seasons when the buds are in the pink, but after the petals fall it is too late to get the best results.

10. Spraying is not likely to control the leaf-curl of plum.

RECOMMENDATIONS

1. Now that a simple practical way has been discovered for the control of this plum pocket and the leaf-gall mite, the growing of

Americana plums should be encouraged in eastern Montana, especially in the valleys of the Yellowstone River and its tributaries. Small home orchards of this fruit should become rather common but the extent to which it may be raised commercially remains to be determined.

2. Limited observations indicate that the better strains of the wild plum, and DeSoto, Hawkeye, Wolf, and Wyant, derived from it, are well suited to the Yellowstone Valley.

3. To control plum pocket or leaf-gall mite or both, give one application of lime-sulphur (28° Baume, diluted 1 to 50) just before the fruit buds open. If rain follows within two days after spraying, repeat the operation.

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